

REMARKS

Claims 37-68 are pending, of which claims 38-54, 67 and 68 are withdrawn from consideration as being directed to a non-elected invention.

Claims 37, 55-60, 63 and 64 were rejected under 35 U.S.C. § 103(a) as being unpatentable over Kawano (JP 2003-17420; Machine translation was used for examination purposes) in view of Guo et al (US 2004/0119063, "Guo").

This rejection should be withdrawn because Kawano and Guo do not disclose or render obvious the present invention, either alone or in combination.

The Examiner acknowledged that Kawano does not disclose the presently claimed repetition number of said higher concentration layer and said lower concentration layer of 10 to 1000 and the claimed thickness of a repetition cycle being 1 nm to 1000 nm.

Guo was newly cited as teaching, in Fig. 1 and paragraph [0034], aluminum nitride and gallium nitride superlattice repetition layers **20** and **22** with 5-15 repetitions of layers **20** and **22** having a thickness on the order of 10 nm or less.

The Examiner concluded that it is reasonable to assume that one would optimize the repetition number and thickness of the superlattice layer, i.e., Applicant's high and low concentration GaN layers to obtain a desirable output, and that it would have been obvious to form the repetition number of 10 to 1000 of said higher concentration layer and said lower concentration layer and a thickness of a repetition cycle of 1 nm to 1000 nm through routine experimentation of the film deposition chemistry and parameters.

The Examiner further stated that there is no evidence indicating that the ranges of the repetition number and thickness are critical and that it is not inventive to discover the optimum

or workable range of a result-effective variable within given prior art conditions by routine experimentation. See MPEP 2144.05.

Applicants respectfully disagree.

As explained in the Amendment under 37 C.F.R. § 1.111 filed August 7, 2009, Kawano does not teach that “a thickness of a repetition cycle is 1 nanometer (nm) to 1000 nm”, as required by the present claims.

Specifically, Kawano discloses in paragraph [0027] that the thickness of the first gallium nitride system compound semiconductor layer should be 5 micrometers (μm) (5000 nm) or more, and preferably 15 μm (15,000 nm) or more in order to broadly bend threading dislocation. Kawano also discloses that the thickness of the second gallium nitride system compound semiconductor layer should be 5 μm (5000 nm) or more, and preferably 15 μm (15,000 nm) or more so that a loop is formed to reduce threading dislocations. Accordingly, the sum of the thickness of the first gallium nitride system compound semiconductor layer and that of the second gallium nitride system compound semiconductor layer is 10 μm (10,000 nm) or more, and preferably 30 μm (30,000 nm) or more, which thickness is well outside the claimed thickness range of a repetition cycle of 1 nm to 1000 nm.

Although Guo teaches a superlattice with 5-15 repetitions of layers **20** and **22** having a thickness on the order of 10 nm or less, the Examiner has not identified a reason that would have prompted a person of ordinary skill in the relevant field to combine (or modify) the elements in the way that the claimed new invention does. *KSR International Co.* The Examiner’s reasoning, such as that one would optimize the repetition number and thickness of the superlattice layer, i.e., Applicant’s high and low concentration GaN layers for desirable output, is based on improper hindsight.

Further, the specification at page 15, lines 15-26 discloses:

In a repetition cycle, the sum of the thickness of the higher concentration layer and that of the lower concentration layer; i.e., the thickness of a repetition cycle, is suitably 1 nm to 1,000 nm, preferably 4 nm to 400 nm, more preferably 6 nm to 100 nm. When the thickness is more than 1,000 nm, pit formation fails to be prevented, or resistance of the n-type impurity concentration periodic variation layer increases. When the total thickness is less than 1 nm, the supply amount of n-type dopant source must be frequently modified, thereby lowering operation efficiency.

Kawano and Guo do not teach or suggest the superior results provided by the present invention.

Still further, modifying the device of Kawano so as to adopt the superlattice structure of Guo would render Kawano's device unsuitable for its intended purpose as explained below.

As disclosed in paragraph [0010] of Kawano, in Kawano's gallium nitride-based compound semiconductor layered structure, an island-like n-type impurity atom higher concentration layer grows in the first place and successively an n-type impurity atom lower concentration layer grows so as to combine adjacent islands. Since the threading dislocation extends perpendicularly to the surface of the island, while adjacent islands are combined, the threading dislocations are bended and thus form loop to reduce. As a result, the threading dislocations, which are in the range of $1 \times 10^8/\text{cm}^2$ to $1 \times 10^{10}/\text{cm}^2$ in the conventional technology, are reduced to $1 \times 10^8/\text{cm}^2$ or less, and preferably $1 \times 10^6/\text{cm}^2$ or less.

Further, as disclosed in paragraph [0027] of Kawano, the thickness of the n-type impurity atom higher concentration layer should be 5 μm or more, and preferably 15 μm or more; this is

because that when the thickness of the n-type impurity atom higher concentration layer is 5 μm or less, the threading dislocations cannot be bended extensively. When the thickness of the n-type impurity atom lower concentration layer is 5 μm or more, and preferably 15 μm or more, the threading dislocations form loop to reduce.

Therefore, one skilled in the art would not have been motivated to adopt the superlattice structure of Guo, where the thickness of each layer is 10 nm or less, as the n-type impurity atom higher or lower concentration layer of Kawano.

Although the superlattice structure of Guo serves as “filter” which limits propagation of the threading dislocations, the threading dislocations, which are in the range of $1 \times 10^8/\text{cm}^2$ to $1 \times 10^{10}/\text{cm}^2$ in the conventional technology, may not be reduced to $1 \times 10^6/\text{cm}^2$ or less, as disclosed in Kawano.

Accordingly, the present claims are not obvious and are patentable over Kawano and Guo, either alone or in combination.

In view of the above, reconsideration and withdrawal of the §103(a) rejection based on Kawano in view of Guo are respectfully requested.

Claims 61 and 62 were rejected under 35 U.S.C. §103 (a) as being unpatentable over Kawano in view of Guo and further in view of Seki et al (US 5,129,986, “Seki”).

This rejection should be withdrawn for at least the same reasons that the §103(a) rejection based on Kawano in view of Guo should be withdrawn, as discussed above, and for the additional reasons set forth below.

Seki was cited as teaching that a higher inert (i.e. carrier) gas flow rate reduces the dopant concentration due to evaporation of the dopant (col. 3, lines 40-47).

However, Seki relates to CZ method-type single crystal silicon (col. 1, lines 12 to 22) and thus belongs to a field different from those of Kawano and Guo.

Therefore, there is no motivation for one skilled in the art to combine the teaching of Seki with the teachings of Kawano and Guo.

Further, Seki discloses that the evaporation rate of the dopant increases and thereby the dopant concentration of the polycrystal melt is decreased, by increasing the carrier gas flow rate. However, in the present invention, the purpose of increasing the carrier gas flow rate is to accelerate the two-dimensional growth of the lower concentration layer to effectively fill up pits produced in the higher concentration layer. That is, the effect obtained by increasing the carrier gas flow rate is different between the present invention and Seki. Therefore, even if Seki was combined with Kawano and Guo, the present invention would not have been arrived at.

Claims 65 and 66 were rejected under 35 U.S.C. §103 (a) as being unpatentable over Kawano in view of Guo and further in view of Anayama (US 5,862,166).

This rejection should be withdrawn for at least the same reasons that the §103(a) rejection based on Kawano in view of Guo should be withdrawn, as discussed above, and for the additional reasons set forth below.

Anayama was cited as assertedly teaching that the nitrogen/III ratio in the growth of the lower concentration layer is lower than the nitrogen/III ratio in the growth of the n-type impurity atom higher concentration layer (col. 8, lines 40-60). Anayama was further cited as teaching that V/III ratio has an effect on pit density (col. 7, lines 45-50).

However, although Anayama teaches V/III ratios of 330 and 160 for the n-type clad layers **22** and **23**, respectively, at col. 8, lines 41-59, the carrier concentration of the two layers **22** and **23** are the same, i.e., $5 \times 10^{17} \text{ cm}^{-3}$. In other words, Anayama does not teach that the

nitrogen/III ratio in the growth of the lower concentration layer is lower than the nitrogen/III ratio in the growth of the n-type impurity atom higher concentration layer as asserted by the Examiner.

Allowance of claims 37 and 55-66 is respectfully requested. If any points remain in issue which the Examiner feels may be best resolved through a personal or telephone interview, the Examiner is kindly requested to contact the undersigned at the telephone number listed below.

The USPTO is directed and authorized to charge all required fees, except for the Issue Fee and the Publication Fee, to Deposit Account No. 19-4880. Please also credit any overpayments to said Deposit Account.

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